

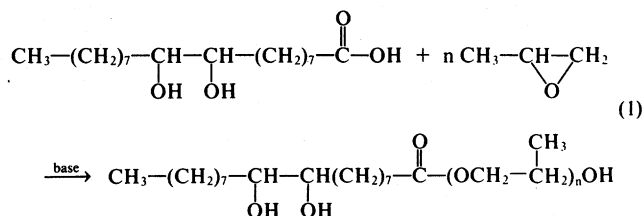
Urethane Coatings From Propoxylated Fatty Acids And Epoxidized Tallow

M. Zubillaga and E. Saggese
United States Department of Agriculture*

Threo- and *erythro*-9,10-dihydroxystearic acid and azelaic acid were reacted with varying amounts of propylene oxide under basic catalysis to form polyether polyols with hydroxyl numbers ranging from 165 to 320. The polyols were evaluated as resin components in coating formulations with three commercial polymeric isocyanates. The fatty acid-based coatings were compared with coatings obtained from three commercial polyols. The properties of the films from fatty acid-derived polyols were similar to those of the controls. Additional films were prepared with the fatty polyols derived from the propoxylated products from the reaction of epoxidized tallow with sorbitol or lactitol. This latter work expands the use of polyols derived primarily from vegetable oils to include those of animal origin.

INTRODUCTION

Previous work in this laboratory demonstrated that polyols derived from epoxidized tallow or hydroxylated fatty acids can be utilized as resin components in the preparation of low, medium, and high density polyurethane foams.¹⁻³ In other studies, hydroxylated fatty acids have been used as components in the formulation of polyester films.^{4,5} The results of the urethane foam studies suggested utilizing propoxylated fatty polyols as resin components in polyurethane coating formulations. To test this feasibility, several series of fat-based polyols were prepared for use as resin components in such formulations. Two series were prepared by reacting propylene oxide with *threo*- and *erythro*-9,10-dihydroxystearic acid to give polyols having a functionality (average number of reactive sites) of three. The reaction is summarized by equation (1), in which *n* has the average value of 3, 5, and 11.



As with simple carboxylic acids,⁶ it is considered that the acid group is consumed in the first stages of reaction with propylene oxide to form propylene glycol monoesters. With additional propylene oxide, reaction presumably continues to a larger extent at the β -oxypropanol, and to a small extent at the vicinal secondary glycol function, still disfavored by comparatively low acidities. Owing to self-alcoholysis during propoxylation, the products are more complex than diagrammed and comprise a mixture of monoesters, diesters, and free polypropylene glycols.^{7,8}

The series corresponding to the reaction of approximately 3, 5, and 11 moles of propylene oxide per mole of *threo*- and *erythro*-9,10-dihydroxystearic acids were designated as the T series and the E series, respectively. An additional series was prepared from azelaic acid to give polyols having a functionality of two. The azelaic acid series, in which about 2, 4, and 8 moles of propylene oxide were fixed, was designated as the Az series. The reaction sequence illustrated by equation (1) was also employed in preparing the azelaic acid series. In this series, the product mixture has hydroxyl units at both ends of the chain.

The polyols described above were reacted with two aromatic and one aliphatic commercial polyisocyanates. A two-package, Type V (ASTM) nonaqueous system containing either 60% or 100% nonvolatiles (NV) was used in this study. The ratio of NCO/OH equivalents used was 1.1 to 1. The solvent was a 1:1 mixture of Aromatic 100 and xylene. Another series of propoxylated polyols of functionality greater than three was obtained with esters resulting from the reaction of epoxidized tallow with sorbitol or lactitol, which were

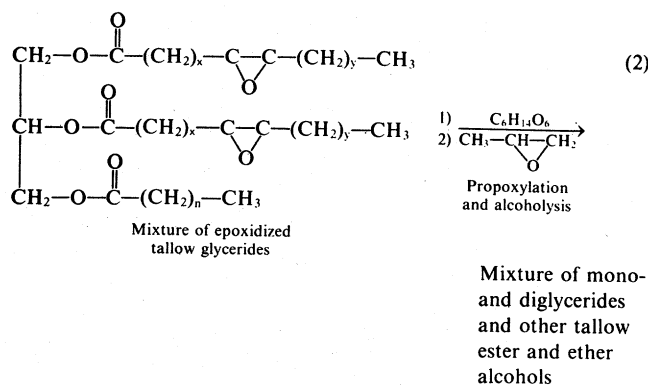
Table 1—Polyols

| Polyols ^a | Hydroxyl Number | Viscosity cps 25°C |
|------------------------------------|-----------------|-----------------------|
| Az ₁ ^b | 321.4 | 990 |
| E ₁ | 324.4 | 1100 |
| T ₁ | 327.1 | 1240 |
| Az ₂ ^b | 248.2 | 340 |
| E ₂ | 286.1 | 180 |
| T ₂ | 280 | 420 |
| Az ₃ ^b | 176.2 | 320 |
| E ₃ | 181.1 | 220 |
| T ₃ | 187.8 | 440 |
| St ₁ | 517.4 | 23000 |
| St ₂ | 356.2 | 3340 |
| Lt ₁ | 334.2 | — |
| Lt ₂ | 300.7 | — |
| Lt ₃ | 270.4 | 3600 |
| F 13 | 341.9 | 880 |
| F 15 | 257.8 | 450 |
| CO DB | 175.1 | 770 |

(a) Propoxylated azelaic acid: Az₁, Az₂, Az₃; propoxylated *erythro*-9,10-dihydroxystearic acid: E₁, E₂, E₃; propoxylated *threo*-9,10-dihydroxystearic acid: T₁, T₂, T₃; propoxylated sorbitol esters of tallow fatty acids: St₁, St₂; propoxylated lactitol esters of tallow fatty acids: Lt₁, Lt₂, Lt₃; glycerol monoricinoleate: F 13; ethylene glycol monoricinoleate: F 15; Castor oil DB: CO DB.

(b) Ascending order of subscripts indicates increasing degree of propoxylation.

designated as St and Lt series, respectively. The reaction sequence is schematically shown with sorbitol by equation (2).



Under appropriate conditions of acid followed by basic catalysis, each epoxy group gave rise, by reaction with propoxylated sorbitol, to six hydroxyl groups. Under basic catalysis, the alcoholysis of glyceride linkage occurred. In addition, this alcoholysis of glyceride linkage conferred hydroxyl functionality even on the wholly saturated triglyceride. The reaction product consisted of a mixture including diglycerides, monoglycerides, fatty esters of propylated sorbitol, and sorbitol hydroxy ethers of the mixed glyceride.⁹ These polyols were evaluated as resin components in coatings to determine the effect of using fatty polyols of high functionality on resultant properties. Subscripts (1, 2, and 3) are used to show progressive increase in propoxylation in each series (Table 1).

It was anticipated that the fat-based polyols, because

of their inherent plasticizing capacity, hydrophobic character, and good thermal stability, might impart improved properties to protective coatings. This work represents a preliminary study for determining the feasibility of utilizing fatty acid-derived materials from animal fats in the urethane coating field.

EXPERIMENTAL

Materials

Threo- and *erythro*-9,10-dihydroxystearic acids were prepared from oleic acid as previously described.^{10,11} The propoxylated sorbitol and lactitol esters of tallow fatty acids were prepared in this laboratory by Bilyk and Monroe according to standard methods.⁶ The following materials were used as received from commercial suppliers: azelaic acid, propylene oxide, and the solvents xylene and Aromatic® 100 (Exxon Co.,* U.S.A.). The isocyanate resins† were Mondur® CB-75, Desmodur® N-75, and Mondur MRS (Mobay Chemical Corp.). The commercial polyols employed were Castor Oil DB (low acidity and moisture content), Flexricin® 13, and Flexricin 15 (NL Industries, Inc.). The flow agent and catalyst were Modaflow® (Monsanto Co.) and Desmorapid® PP (Mobay Chemical Corp.), respectively.

Propoxylated *Threo*-9,10-dihydroxystearic Acid

The propoxylated reaction used in this study was based on literature procedure.⁶ Into a 500 ml 3-neck round bottom flask, equipped with a condenser, mechanical stirrer, addition funnel, and thermometer, was placed 79.5 g (0.25 mole) *threo*-9,10-dihydroxystearic acid and 0.46 g of potassium hydroxide, 0.5% based on weight of acid. The mixture was heated to 130°C under a N₂ atmosphere, and propylene oxide (43.5 g; 0.75 mole) was added dropwise over a period of 2 hr. The temperature was then increased to 155°C for an additional hour. After cooling to ambient temperature, the mixture was dissolved in chloroform (200 ml), and the catalyst was neutralized with concentrated hydrochloric acid. The inorganic salts were filtered off and the solvent was removed on a rotary evaporator. The polyol weighed 122 g (hydroxyl number, 327.1, Table 1).

In a similar manner, a series of propoxylated *erythro*-9,10-dihydroxystearic derivatives and another of azelaic acid derivatives were prepared (Table 1).

Coating Preparation

The following technique was used to prepare all of the coatings in this study except for specific modifications as noted. The ratio of NCO/OH eq. wt. used was 1.1 to 1.

Into a 2 oz polyethylene cup was placed 5.15 g of polyol T₁ (OH eq. wt. 171.5) and 5.17 g each of dry xylene and Aromatic 100. To this was added 0.31 g of the flow agent, Modaflow (5% ethyl acetate solution, 0.1% based on total weight of resin). The polyol was mixed and

*Reference to brand or firm name does not constitute endorsement by the U.S. Dept. of Agriculture over others of a similar nature not mentioned.

†Proper precautionary measures should be exercised when handling isocyanate resins in view of their suspected toxicological properties.

evaluated as only fair. The coating prepared from Az₁ series showed some signs of cloudiness in the boiling water test after 5 min and some vapor condensation in the water immersion test after three weeks. The polyols with hydroxyl number in the 250 range (subseries 2) gave coatings with appearances as good as and hardness values generally higher than those of the control. The polyols with hydroxyl numbers in the 180 range (subseries 3) gave poor films with Mondur MRS. The films showed some degree of tackiness after being cured and exhibited a greater wetting ability on metal than on glass. Tack free times for the azelaic acid series varied from 3 to 12 hr, hard-to-touch times from 6 to 48 hr, and pot life times from 12 to 24 hr. The latter increased with decreasing hydroxyl number of the polyol. By comparison, the E and T polyols gave films with drying times of 3 to 4 hr and pot life values of 0.5 to 1 hr.

A separate series of propoxylated sorbitol esters of epoxidized tallow (St series) was also utilized as polyol resin components. These polyols were selected from a larger series previously used in urethane foam formulations.¹² This series was formulated with the polyisocyanate Mondur CB-75 with and without the aid of a flow agent and was allowed to react for 10 min prior to application to the substrates. Pot life for the coating formulations with a flow agent was 1.5 hr, whereas that for those without a flow agent was only 20 min. All of the films cast from this series of polyols had hard-to-touch times of 20 min. The results noted for the coatings formulated from this series are given in Table 7. Films from a polyol with high hydroxyl number (St₁) had very good appearance and high hardness values but relatively low elasticity (10% elongation). The polyol with lower hydroxyl number (St₂) gave films with hardness and appearance similar to those with St₁ but only 5% elongation. The lower elasticity values for this series of films are probably due to the higher polyol functionality which results in a more highly crosslinked polymer network in the final urethane film. The chemical resistance tests were acceptable except for the films formulated with Mondur CB-75 and additives which turned hazy after immersion in water for three weeks.

The polyols in the St series, also shown in Table 7, were formulated with Desmodur N-75, with a flow agent and Desmorapid PP used as catalyst. The mixtures were allowed to stand for 30 min before application and had a pot life of 1.5 hr. Although the hardness values were somewhat reduced from those films formulated with Mondur CB-75, the elasticity was improved to >60% elongation. The films from this series had very good appearance and acceptable chemical resistance. The hardness values for the St₂ films were approximately one-half of those given by the St₁ films.

Coatings were also cast from formulations containing propoxylated lactitol esters of tallow fatty acid polyols

(Lt) and the polyisocyanates Mondur CB-75 and Desmodur N-75. In this series, however, polyols with hydroxyl numbers greater than 270 failed to produce acceptable coatings in all the formulations studied. Those polyols with a low degree of propoxylation gelled when mixed with these isocyanates. The Lt₃ polyol with hydroxyl number 270, however, did produce acceptable films when formulated with the above isocyanates (Table 8). Reaction time, drying time, and pot life for these coating formulations closely paralleled those noted for the St series of polyols. The hardness values and appearance were generally comparable to those observed for the St series of films. However, their flexibility values, when formulated with Mondur CB-75, were superior to the tallow sorbitol polyols.

CONCLUSION

It was found that the preparation of protective urethane coatings from new fat-based intermediate polyols is feasible. This study indicates a new area for the use of tallow in commercial application. The final cured coatings from tallow contained between 8.4 and 13.5% fatty material.

The criterion used in this study was such as to permit an objective determination of the practicability of making protective urethane coatings from animal fat derivatives. The physical properties and chemical resistance exhibited by the films cast from high and intermediate hydroxyl number polyol resins were, in general, acceptable.

This study indicated that the fat-based derivatives have a potential use as resin components in coating formulations. The formulations described were arbitrarily selected and not designed for any specific application.

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thoroughly blended with 10.34 g of isocyanate resin, Mondur CB-75 (NCO eq. wt. 313.4). The mixture was allowed to stand for 1 hr before being used. Glass test tubes were dip-coated up to one-half of their length and placed vertically in a tray in an inverted position. The substrate to be coated (glass, tin, steel, and aluminum) was placed on a Howard suction plate, the polymer mixture was poured onto the upper section of the substrate and the film was applied by a Bird Applicator with a pre-fixed clearance of 3 mil. The final dry film thickness was about 1.5 mil. The test tubes and the other coated items were baked in an oven at 148°C for 20 min. After the films were cured by baking, their physical properties and chemical resistance were evaluated. The samples used for drying time evaluation were air dried at RT.

The formulations with Mondur CB-75 were also made without a flow agent. The compositions with Desmodur N-75 required the use of a catalyst (Desmorapid PP, 0.5% based on weight of the resins) and a flow agent; those with Mondur MRS were 100% N.V. and no flow additives were used.

Test Methods

The standard procedures described below were used to evaluate the physical properties and the chemical resistance of the coatings prepared.

DRYING TIME: Tack Free (set-to-touch) and Dried-hard (hard-to-touch) (Federal Test Method Standard 141, Method 4061.1).

HARDNESS: Sward Rocker Tester (American Society of Testing Method D2134-66), glass equals 100.

IMPACT FLEXIBILITY: General Electric Tester (Federal Test Method Standard 141, Method 6226).

CHEMICAL RESISTANCE: Test tubes (12 cm × 1 cm) were dip-coated and immersed one-fourth of their length in the following substances for three weeks except where noted: deionized water at room temperature, boiling water (15

Table 3—Formulations: Application and Baking Times (148°C)

| Polyols | Isocyanate ^a | Formulation Type ^b | Reaction Time (Before Application) | Baking Time (After Application) |
|---|-------------------------|-------------------------------|------------------------------------|---------------------------------|
| Controls ^c and experimental polyols ^d | Mondur CB-75 | A | 1 hr | 20 min |
| | | B | 1 hr | 20 min |
| | Desmodur N-75 | B | 1.5 hr | 30 min |
| | Mondur MRS | A | 15–20 min | 20 min |
| Propoxylated sorbitol esters of tallow fatty acids | Mondur CB-75 | A | 10 min | 20 min |
| | | B | 10 min | 20 min |
| | Desmodur N-75 | B | 30 min | 30 min |
| Propoxylated lactitol esters of tallow fatty acids | Mondur CB-75 | A | 10 min | 20 min |
| | | B | 10 min | 20 min |
| | Desmodur N-75 | B | 30 min | 30 min |

(a) Commercial resins (Mobay Chemical Corp.).

(b) A—no additives; B—additives.

(c) Castor Oil DB, glycerol monoricinoleate (F 13) and ethylene glycol monoricinoleate (F 15).

(d) Propoxylated azelaic acid and propoxylated *threo*- and *erythro*-9,10-dihydroxystearic acid.

min), 10% hydrochloric acid solution, 5% sodium hydroxide solution, and toluene. The samples were examined periodically to determine any changes. Samples which passed the chemical test were designated by a plus sign (+), whereas those that failed were designated by a minus sign (–).

RESULTS AND DISCUSSION

Coatings were prepared from five series of fat-based polyols (Table 1) and from three commercial polyols. Three of the series (Az, E, T) had hydroxyl numbers ranging between 175 and 327; the other two series (St, Lt) had hydroxyl numbers ranging between 270 and 518. For comparison, coatings were also prepared from three commercial polyols (F 13, F 15, CO DB). The control polyols were selected on the basis of their functionality (diol or triol structure) and similarity of hydroxyl numbers with the experimental polyols described herein. Shown in Table 2 are the drying times observed for coatings formulated with and without additives. In general, the drying times increased as polyols with lower hydroxyl numbers were used and were longer for the diol series than for the triol series. This same trend was noted for pot life.

The formulations with flow additive gave films with longer tack free times than those films cast without the additive, whereas hard-to-touch and pot life values were generally similar.

Table 3 summarizes the time allowed between mixing and application to substrate for polyols studied. This time was shorter for the more highly functional polyols, propoxylated sorbitol, and lactitol esters of tallow fatty acids than for the lower functional experimental polyols and controls. The extent of the reaction of the polymer

Table 2—Drying Times^a of Coatings Formulated with Mondur CB-75

| | Polyol Hydroxyl Numbers | | | | | |
|------------------|-------------------------|----------------------|-----------------|--------|-----------------|-------|
| | From 321 to 341 | | From 248 to 280 | | From 175 to 188 | |
| | Diol ^b | Triol ^{c,d} | Diol | Triol | Diol | Triol |
| A | | | | | | |
| (no additives) | | | | | | |
| Tack free | 0.5 | 0.5(3) | 1.5 | 0.5(3) | 2.5 | 2(3) |
| Hard-to-touch .. | 2.5 | 2(3.5) | 4 | 2(3.5) | 4 | 4 |
| Pot life | 24 | 24 | 48 | 24 | 1 week | 24 |
| B | | | | | | |
| (additives) | | | | | | |
| Tack free | 2 | 2 | 2 | 2 | 3.5 | 3 |
| Hard-to-touch .. | 3.5 | 2 | 4 | 2 | 6 | 4 |
| Pot life | 48 | 24 | 48 | 24 | 1 week | 48 |

(a) Time units = hours (RT, 25°C).

(b) Az series polyols and F 15 control polyol.

(c) E and T series polyols and F 13 control polyol.

(d) Values in parentheses are differences noted for E series polyols.

Table 4—Physical Properties and Chemical Resistance of Coatings Formulated with Mondur CB-75^a

| Polyol | Appearance ^b | | Hardness (Glass Plates) Sward Rocker Test | | Chemical Resistance ^c to 5% NAOH | |
|-----------------------|-------------------------|-----------------------|---|----------|--|----------|
| | No Additives | Modaflow ^d | No Additives | Modaflow | No Additives | Modaflow |
| F 13..... | 3 | 3 sn | 60 | 60 | + | + |
| Az ₁ | 3 | 3 | 60 | 40 | + | + |
| E ₁ | 3 | 3 | 46 | 46 | + | 2 weeks |
| T ₁ | 3 | 3 | 50 | 50 | + | 2 weeks |
| F 15..... | 4 | 3 | 60 | 50 | + | 1 week |
| Az ₂ | 4 | 3 | 58 | 40 | + | 1 week |
| E ₂ | 4 | 4 | 60 | 54 | + | 1 week |
| T ₂ | 4 | 4 | 60 | 54 | + | 1 week |
| CO DB..... | 3 | 3 sn | 40 | 16 | + | 3 weeks |
| Az ₃ | 3 | 3 sn | 36 | 30 | + | + |
| E ₃ | 4 | 3 sn | 20 | 20 | + | + |
| T ₃ | 4 | 3 sn | 40 | 40 | + | + |

(a) Commercial resin (Mobay Chemical Corp.).

(b) Numerical rating code based on ASTM D714-56: 4—very good (no signs of imperfections, cratering, blistering, etc), 3—good (some negligible imperfections), 2—fair (moderate visible imperfections), 1—poor (more pronounced imperfections), 0—bad (no film evaluation).

(c) Samples coded + showed no signs of deterioration during three weeks of observation. The chemical resistance to the following media were all (+): deionized water at room temperature, boiling water, 10% hydrochloric acid, and toluene.

(d) sn: (scratched by fingernail).

solution before application is judged by the increase in viscosity which depended on the nature of the polyol and the type of the isocyanate used, aromatic or aliphatic.

Also shown in Table 3 is the baking time. The incorporation of additive did not make any difference in the times noted, but the isocyanate used did. When Desmodur N-75 was used instead of Mondur CB-75 the reaction time increased because the viscosity increased more slowly.

The physical and chemical properties of the films prepared from the fatty acid-derived polyols and controls reacted with Mondur CB-75 are given in Table 4. In general, all of the coatings cast with this polyisocyanate gave films whose appearance, hardness, impact flexi-

bility, and chemical resistance were similar to those of the controls, except that about half the films prepared with the use of a flow agent exhibited some loss in hardness and reduced chemical resistance to alkali. The experimental polyols with higher hydroxyl numbers (subseries 1) gave films with lower hardness values than the control F 13, whereas the intermediate (subseries 2) and low hydroxyl number polyols (subseries 3) had hardness values similar to or higher than those of the controls (F 15, CO DB). Films obtained with the E series of polyols had lower hardness values than those obtained from the T series polyols. It is assumed that this difference is due to the diastereomeric characteristic of the hydroxyl function between the two series.

Table 5 shows values for the same series of polyols formulated with the aliphatic polyisocyanate Desmodur N-75. Since Desmodur N-75 contains a biuret structure and is a less reactive isocyanate polymer than Mondur CB-75 (urethane structure), a catalyst was used for these formulations. Coatings prepared from the fatty acid-based polyols with high and intermediate hydroxyl numbers (subseries 1 and 2, respectively) exhibited good appearance and impact flexibility of >60% elongation. The films were soft except for the control F 13 and the polyol T₁. Drying times for the films prepared from Desmodur N-75 ranged from 2.5 to 3.0 hr, and pot life for the resin polymers ranged between 24 and 48 hr except for the E₁ polyol formulations, which had drying times as long as 72 hr.

Table 6 gives the data obtained on the coatings prepared from the polyol series reacted with the aromatic polyisocyanate Mondur MRS in a solventless system. The polyols with hydroxyl numbers in the 330 range (subseries 1) had hardness and flexibility values similar to those of the control, while their appearance could be

Table 5—Physical Properties and Chemical Resistance Of Coatings Formulated with Desmodur N-75^a

| Polyol | Appearance ^b | Hardness (Glass Plates) Sward Rocker Test | Chemical Resistance ^c to 5% NAOH |
|-----------------------|-------------------------|---|---|
| F 13..... | 2 | 26 | 1 week |
| Az ₁ | 3 | 6 | 2 weeks ^f |
| E ₁ | 3 | 6 | 2 weeks |
| T ₁ | 3 | 34 | (+) |
| F 15..... | 2 | 4 | 24 hr |
| Az ₂ | 3 ^t | 4 | 1 week |
| E ₂ | 3 | 6 | 1 week |
| T ₂ | 3 | 6 | 1 week |
| Az ₃ | 2 | 2 | 48 hr |

(a)(b)(c) See footnotes for Table 4.

(d) Abbreviation (t) for tacky.

(e) Polyols within this hydroxyl number range (T₁ and E₃ including the control) gave un-acceptable films.

(f) Az₁ in H₂O deteriorated after one week.

Table 6—Physical Properties and Chemical Resistance of Coatings Formulated with Mondur MRS^a with No Additives or Solvents

| Polyols | Appearance ^b | Hardness (Glass Plates) Sward Rocker Test | Chemical Resistance to ^c | | | | |
|-----------------|-------------------------|---|-------------------------------------|---------------|---------|---------|---------|
| | | | Deionized Water Room Temp. | Boiling Water | 10% HCl | 5% NaOH | Toluene |
| F 13 | 2 | 50 | + | + | + | 72 hr | + |
| Az ₁ | 2 | 62 | 3 week D ^e | 5 min | + | + | + |
| T ₁ | 2 | 50 | + | + | + | + | + |
| F 15 | 2 sn ^d | 16 | + | + | + | + | + |
| Az ₂ | 3 | 14 | + | + | + | + | + |
| E ₂ | 3 | 26 | + | + | + | 72 hr | + |
| T ₂ | 3 | 46 | + | + | + | + | + |
| CO DB | 1 t | 0 | + | + | + | 72 hr | + |
| Az ₃ | 3 t | 2 | + | + | + | + | + |
| T ₃ | 1 t f | 4 | + | + | + | 24 hr | + |

(a)(b)(c)(d) See footnotes for Table 4.

(e) D (dew).

(f) t (precipitation).

Table 7—Physical Properties and Chemical Resistance of Coating from Propoxylated Sorbitol Esters of Tallow Fatty Acid Formulated with Mondur CB-75 and Desmodur N-75^a

| Polyol | Appearance ^b | Hardness (Glass Plates) Sward Rocker Tester | % Elongation (Tin Plates) G.E. Impact Flexibility Tester | Chemical ^c Resistance To Deionized Water (Room Temp.) |
|-----------------------------------|-------------------------|--|---|---|
| Mondur CB-75 | | | | |
| St ₁ (No additives) | 4 | 64 | 10 | 3 weeks H ^d |
| St ₁ (Additives) | 4 | 64 | 10 | + |
| St ₂ (No additives) | 3 | 54 | 5 | 3 weeks H |
| St ₂ (Additives) | 3 | 54 | 5 | + |
| Desmodur N-75 | | | | |
| St ₁ (Additives) | 4 | 52 | 60 | + |
| St ₂ (Additives) | 2 | 30 | 60 | + |

(a)(b)(c) See footnotes for Table 4.

(d) H: hazy.

Table 8—Physical Properties and Chemical Resistance of Coatings from Propoxylated Lactitol Esters Of Tallow Fatty Acids (Lt₃) Formulated with Mondur CB-75 and Desmodur N-75^a

| Isocyanate | Appearance ^b | Hardness (Glass Plates) Sward Rocker Test | % Elongation (Tin Plates) G.E. Impact Flexibility Test | Chemical Resistance ^c | | | | |
|--------------------------------|-------------------------|---|---|----------------------------------|----------------|---------|---------|---------|
| | | | | Deionized Water (Room Temp.) | Boiling Water | 10% HCl | 5% NaOH | Toluene |
| Mondur CB-75 (No additives) | 3 | 50 | 20 | + | + | + | + | + |
| Mondur CB-75 (Additives) | 3 | 50 | 40 | + | H ^d | + | + | + |
| Desmodur N-75 (Additives) | 2 | 22 | 40 | + | + | H | 3 weeks | + |

(a)(b)(c) See footnotes for Table 4.

(d) H: Hazy.